Advancing Resource Management at Texas Instrument's Sensors and Controls Facility (Attleboro, MA)

1. OVERVIEW

Texas Instruments Incorporated (TI) is a leading producer of digital signal processing and analog technologies for wireless and broadband applications, and for new and emerging markets such as digital cameras and digital audio. The company's businesses also include sensors and controls, and educational and productivity solutions. TI is headquartered in Dallas, Texas and has manufacturing or sales operations in more than 25 countries, employment of 14,400 worldwide, $12 billion in revenue and is ranked 180th on the Fortune 500 (FY1999).

This case study focuses on Sensors and Controls headquarters (henceforth referred to as TI), located on a 275-acre site in Attleboro, Massachusetts. The 14-building campus has approximately 2,000 employees and occupies over 1 million square feet of office and manufacturing space. With over $1 billion in revenue in 1999, the Sensors and Controls (formerly Materials and Controls) division is a leader in engineered sensors and control devices for the transportation, appliance, HVAC, industrial/commercial, electronic/communication and radio frequency identification markets. These devices are used to improve efficiency and safety in transportation applications (e.g., cars, airplanes), computers, and appliances such as refrigerators and microwaves. In addition to its site in Massachusetts, the group has manufacturing sites in Brazil, Mexico, Holland, Malaysia, Japan, Korea, and China with sales offices located in major countries throughout the world.

Specifically, this analysis baselines the site's current integrated solid waste management program, and examines the extent to which TI is currently practicing RM and how further use of Resource Management (RM) contracting practices could increase recycling and overall material resource efficiency.

2. BASELINE SOLID WASTE AND RECYCLING SERVICES AND LEVELS

The majority of TI's trash hauling/incineration and recycling services is managed through one contractor. Hauling and incineration of materials disposed of by TI in its containers and compactors is provided on a "call" basis with the exception of one container, which is serviced on a regular three-times-a-week schedule. In 2000, nearly 972 tons of material was managed as waste.

Four sub-contractors handle TI's recycling services – separate companies are responsible for paper and cardboard, plastic, processed metal, and scrap metal recycling, respectively. Wood is reused internally, or picked up by the waste contractors and chipped for use as mulch. The campus also engages in recycling oil filters, lightbulbs, and computers on a non-contractual basis through purchase orders.

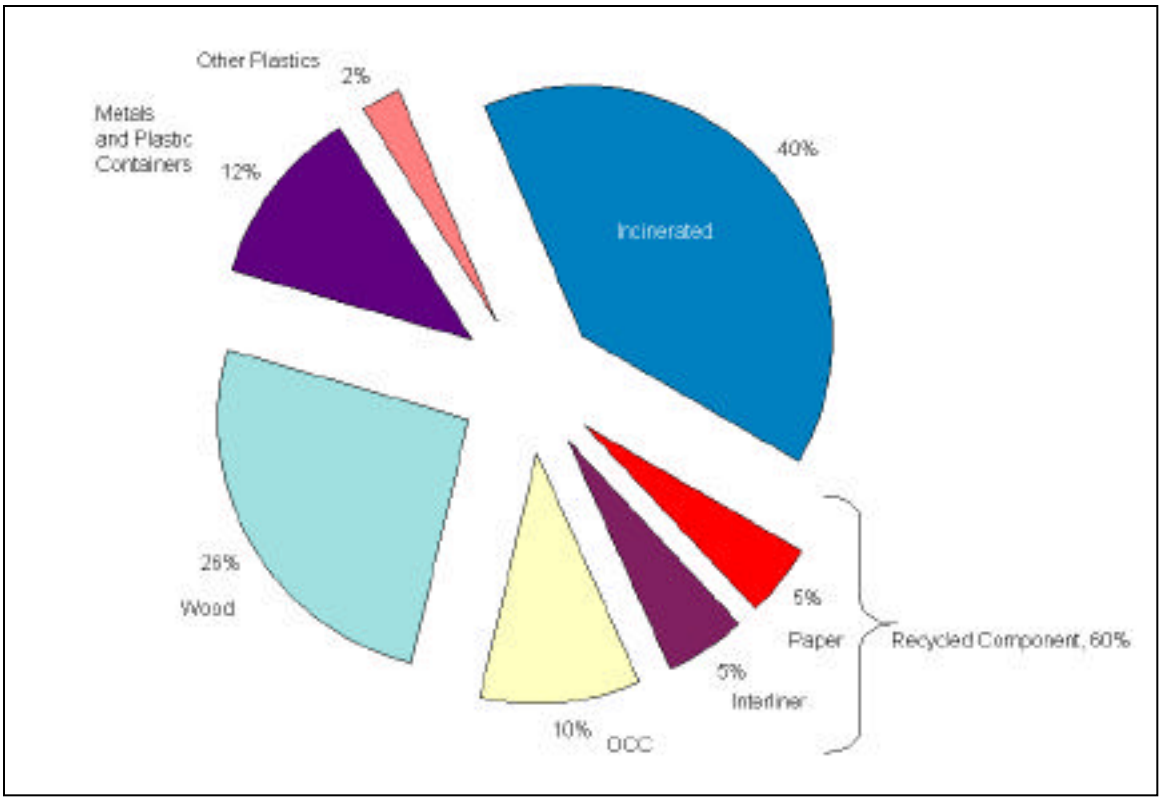

Figure 1: TI Waste/Recycling Profile, CY2000

For its recycling service, TI-owned recycle containers are distributed within buildings, and larger consolidation containers are provided for certain bulk materials (e.g., interliner paper, scrap metal, wood pallets). All white interliner paper is fed directly into the paper compactor (Table 1) as it is separated from the process materials it is used to protect. Other materials recycled by TI in 2000 include mixed paper and magazines, corrugated cardboard, plastics, wood, and scrap metals (Figure 1). Since 1999, the tonnage of material recycled has exceeded that being incinerated.

There are three internal parties that support material handling and processing prior to contractor pick-up. First, the custodial contractor is responsible for internal handling of trash, consolidation of recyclables, and transport to the appropriate container at the nearest loading dock. At six of the smaller buildings without shipping/receiving areas, the custodial contractor transports trash and recyclables to the nearest shipping area in one of the other nine larger buildings (Table 1). In addition to their daily recycling activities, certain TI employees bail corrugated cardboard and other recyclables (e.g., plastics). From this point, the Metals Recovery Department (MRD) is responsible for emptying bailers and transporting all recyclable material from loading docks to the central scrap yard. The waste contractor and recycling sub-contractors handle the material from this location.

TI has also formed an internal recycling team that has led several recycling initiatives by using revenue generated from recyclable materials to cover recycling resources (e.g., bailers, totes, signage) and employee recognition dinners for departments that have demonstrated high participation and recycling rates.

There are a number of trash and recycling containers and equipment located at the ten largest buildings on the TI campus (Table 1). TI owns most of its compactors and bailers, and rents its open containers. The campus has an average of 18 pick-ups per month for all containers and compactors.

Table 1: TI Waste and Recycling Equipment Summary

Building	Waste Service	Recycling Service*
B-1	1 35-cu.yd. compactor	▪ 1 cardboard bailer
B-2	1 5-cu.yd compactor	---
B-10	1 35-cu.yd. compactor	▪ 1 cardboard bailer
B-11	2 30-cu.yd. open (1 scheduled service, 1 on-call)	▪ 2 cardboard bailers ▪ 1 35-cu.yd. compactor for interliner paper ▪ 1 50-cu.yd. open (scrap metals)
B-12	1 35-cu.yd. compactor	▪ 1 cardboard bailer ▪ 50-cu.yd. open for wood pallets
B-14	1 35-cu.yd. compactor	▪ 1 cardboard bailer
B-20	1 35-cu.yd. compactor	---
B-22	1 30-cu.yd. temporary container	---
B-23	1 8-cu.yd. open	---

* All buildings have recycle totes for various materials; this service description reflects large containers and other capital equipment for recycling.

Twice annually, TI conducts visual waste audits at select containers with the assistance of its waste/recycling contractor to spot assess its waste stream. TI uses this exercise as an opportunity to identify potential for increased diversion, and it has supported improvement of TI's source reduction and recycling program over the last several years. TI achieved a 41% recycle rate for non-hazardous solid waste[1] in 1998, falling just short of its 50% goal, while in 1999 and 2000, the established goals of 55% and 60% recycle rates were achieved (Figure 2). A 65% target has been set for 2001, and a 60% level was attained in the first quarter. Cost savings as a result of higher recycle rates in 2000 are estimated at $157,000.[2]

[1] This rate excludes process metals.

[2] TI's estimate based on the tonnage recycled and haul/tip fees that would have been associated with incineration of all material recycled in CY2000.

Figure 2: TI Waste/Recycling Summary, 1995-First Quarter 2001

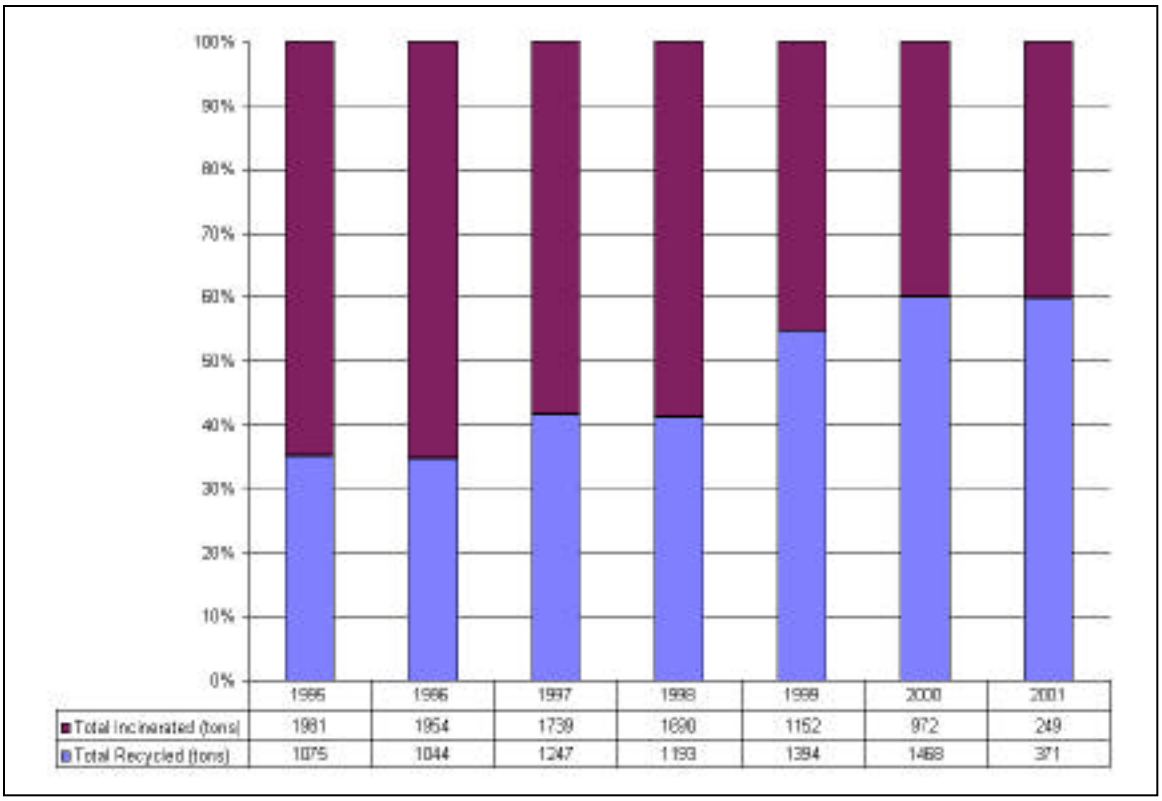

Table 2: TI CY2000 Estimated Capture Rates for Select Materials

Material	Tons Captured	Estimated Tons in Waste (1)	Estimated Total Tons	Estimated Capture Rate
Paper (Mixed, including interliner)	244.1	291.5	535.6	45.7%
Corrugated Cardboard	125.7	64.1	189.9	66.2%
Plastic	30.2	165.2	195.4	15.4%
Non-processed metals	140.7	111.8	252.4	55.7%

(1) Conservative estimates based on California Integrated Waste Management Board Waste data (http://www.ciwmb.ca.gov/WasteChar/BizGrpCp.asp).

3. BASELINE CONTRACTS AND COMPENSATION

TI has one contract for the trash and recycling services described in section 2. Under the trash component of the current contract, TI pays $135 per haul and a $70 per ton incineration fee. In 2000, TI reports paying approximately $31,000 in hauling fees, and $136,000 in incineration fees, for a total of $167,000. This amounts to $171.85 per ton for hauling (estimated 19 per month, 230 per year) and disposal (972 tons).

For its recycling services, TI pays no fees, and receives a percentage of commodity value of materials it recycles based on current markets. Revenues on all recyclable materials amounted to roughly $20,000 in 2000. These funds are used to finance recycling equipment purchases (i.e., bailers and containers), and to hold appreciation dinners for those departments exhibiting commitment and demonstrated results in recycling and source reduction.

4. OPPORTUNITIES FOR COST SAVINGS AND ENHANCED RECYCLING SERVICES

TI has made impressive progress since 1995 diverting a higher percentage of the material resources not used in its products. TI Attleboro's environmental objectives for 1998 includes the desire to "generate business value through resource optimizations and human productivity enhancement"[3], which fits well within the conceptual framework of resource management. TI has also established ambitious "Zero-Zero" goals that strive for 100% process efficiency by reusing, recycling and regenerating any material not incorporated into its products. Partnerships with suppliers are promoted as a means to advance the 100% process efficiency goals.

While a 60% recycle rate is commendable, there are undoubtedly further opportunities to increase diversion and initiate source reduction activities. One means to leverage incremental improvements in recycling and resource efficiency while maintaining or even decreasing program costs is to restructure and further coordinate contracts and recycling programs to be even more consistent with Resource Management (RM) practices. This is a departure from the current focus on recouping enough recyclable commodity revenue internally to finance recycling equipment and other recycling program components. RM would instead focus on distributing avoided trash incineration/haul costs by providing a portion or all commodity revenues to the contractor as compensation for optimizing trash and recycling activities. This provides an incentive for contractors (not just TI employees) to maximize cost-effective diversion and source reduction.

To assess recycling opportunities under an RM contract, TI waste stream composition was estimated based on adjusted waste stream profiles for electronic equipment manufacturers developed by the California Integrated Waste Management Board.[4] The

[3] 1998 Report on the Environment, TI Materials and Controls.
[4] Conservative estimates based on California Integrated Waste Management Board Waste data (http://www.ciwmb.ca.gov/WasteChar/BizGrpCp.asp).

most significant adjustment was based on high estimated capture rates for interliner paper. Tables 2 and 3 present three scenarios projecting incremental improvements from estimated baseline recovery rates that may be possible at TI. The particular materials chosen as the focus for this analysis represent the "low-hanging" fruit – materials for which the capture rate could be most readily increased. Other materials, such as scrap metal and corrugated cardboard, were omitted from the analysis due to high existing capture rates (Table 4). Focusing on these materials would make incremental improvements more costly and difficult to achieve.

Table 3: Effects of Increased Recycling on TI Contract Costs, by Material

Material	Scenario Name (1)	Capture Rate of Material	Tonnage of Material Recovered	Avoided Incineration Fee (2)	Avoided Hauling Cost (3)	Revenue (4)	Total Savings
Mixed Paper (including interliner)	Current	45.7%	244.00	$17,080	$3,660	$500	$21,240
	Scenario 1	50.0%	267.79	$18,745	$4,017	$549	$23,311
	Scenario 2	65.0%	348.13	$24,369	$5,222	$714	$30,304
	Scenario 3	75.0%	401.68	$28,118	$6,025	$823	$34,967
Plastic and Glass	Current	15.4%	30.09	$2,106	$451	$62	$2,619
	Scenario 1	25.0%	48.84	$3,419	$733	$100	$4,252
	Scenario 2	35.0%	68.38	$4,786	$1,026	$140	$5,952
	Scenario 3	45.0%	87.92	$6,154	$1,319	$180	$7,653
Construction and Demolition Debris (5)	Current	0.0%	0.00	$0	$0	NA	$0
	Scenario 1	15.0%	19.10	$1,337	$286	NA	$1,623
	Scenario 2	35.0%	44.56	$3,119	$668	NA	$3,787
	Scenario 3	60.0%	76.38	$5,347	$1,146	NA	$6,492
Organics (6)	Current	0.0%	0.00	$0	$0	NA	$0
	Scenario 1	15.0%	15.74	$1,102	$236	NA	$1,338
	Scenario 2	35.0%	36.73	$2,571	$551	NA	$3,122
	Scenario 3	60.0%	62.97	$4,408	$945	NA	$5,352

(1) Scenarios were developed based on capture rates for different materials within the different types of organizations, thus capture rates vary by organization. Incremental gains for a material with a relatively high capture rate in one organization would be more modest than for organizations with lower capture rates of the same material. Readily available sector based waste composition data was used to estimate the capture rates. When actual waste composition data was not available California Integrated Waste Management Board standards were used. Scenarios were calculated showing incremental gains for each chosen material. Materials such as paper, cardboard, glass, plastics and organics with readily available secondary markets were chosen.

(2) Estimated on incineration fee of $70/ton.

(3) These are estimated assuming 50% variable costs.

(4) Assumes a conservative $2.05 per ton rate for mixed paper and cardboard based on experience with other Massachusetts organizations.

(5) Construction and Demolition Debris comes from construction and renovation projects at the facility.

(6) Organics refers primarily to food residuals from cafeteria waste and landscaping debris.

Table 4: Summary of Potential TI Cost Savings for Increased Recycling of Paper, Plastic and Glass, Construction and Demolition Debris, and Organics (Table 2)

Scenario	Tonnage Material Recovered	Avoided Incineration Fee	Avoided Hauling Cost	Revenue	Total Savings	Total Savings from Baseline	Savings as % of Total Contract Costs	Resulting Net Recycle Rate
Current	274	$19,186	$4,111	$562	$23,859	NA	NA	60%
Scenario 1	351	$24,603	$5,272	$649	$30,524	$6,665	4.0%	63.3%
Scenario 2	498	$34,845	$7,467	$854	$43,166	$19,307	11.6%	69.3%
Scenario 3	629	$44,026	$9,434	$1,004	$54,464	$30,605	18.3%	74.7%

Despite high capture rates for some materials, it appears based on estimated waste stream profiles that there remains a significant tonnage of recyclable, compostable or recoverable material in TI's waste stream. Presently, the burden of recovering materials rests solely on TI, with recycling contractors simply picking up whatever TI can recover. Providing a financial incentive to contractors to help TI remove more material can help increase recycling rates with no additional cost to TI.

Jointly, avoided incineration and hauling costs and recyclable commodity values increase with higher recycling rates (Table 2 and 3). The scenarios suggest potential cost savings of between $6,665 and $30,605, representing between 4% and 18% of the affected service based on approximately $167,000. These savings represent estimates of "gain-sharing" that may be distributed in part or entirely to the contactor as part of a restructured compensation package to provide direct financial incentives for resource efficiency, and/or to fund internal recycling and source reduction initiatives. Moreover, the nature of compensation under a gain-sharing arrangement shifts the onus onto the contractor to identify and propose activities to increase recycling and source reduction.

As the scenarios above suggest, TI and its RM contractor might initially focus on increasing recycling rates from the baseline for those materials with lower capture rates. However, there exists a point of diminishing return at which the resources required to achieve incremental gains in diversion may be uneconomical. At this point, source reduction opportunities and additional services will become the focus of the RM program. Thus, while RM typically begins with a focus on restructuring contracts to motivate increased diversion, the new compensation mechanism should create incentives for the contractor to move further upstream to focus on source reduction and other value-added activities (e.g., training of employees in material conservation techniques). The viability and attractiveness of RM to a contractor will depend on its ability to ensure long-term profitability through strategic and equitable partnerships with customers.

5. REALIZING COST EFFECTIVE RECYCLING AND REDUCTION POTENTIAL WITH RM CONTRACTING

Several standard practices can be followed to prepare for and implement an RM contract (Table 5). TI has implemented several of these practices either partially or completely, while others are not yet in place. These practices align customer and contractor incentives for resource efficiency by establishing a compensation mechanism based on performance and continuous service improvement. The first practice, baselining current cost, performance, and service levels is embodied in this memo. This baseline provides the foundation for implementing Practices 2-6, which are essential components of developing a request for proposal or other competitive bid document soliciting RM services.

An assessment was conducted to determine the extent to which RM practices were part of existing contracting at TI. Those practices that are currently in place (Table 5) are RM practices that are the most mature or best established in TI's current contracts and practices. There is potential to adopt remaining RM contracting practices or enhance others to leverage recycling improvements as a cost neutral (or even cost saving) proposition.

1. *Establish baseline cost, performance, and service levels.* TI has been carefully tracking and documenting its recycling and trash service levels since 1995. As part of its environmental policy and reporting initiative, TI has also established specific performance goals based on reasonably foreseeable improvements from baseline recycling and waste reduction levels. For CY2001, these goals include a 5% reduction in campus waste generation from 2000 levels, and attaining a 65% recycle rate, excluding process metals.

   While the waste and recycling service levels are well established, associated costs, which are anticipated to be low compared with other operating costs, are monitored or documented less systematically. Estimates of total contract costs for hauling ($31,000) and incineration ($136,000) components of trash service do not concur with reported service levels.[5] In addition, the costs of recycling are not tracked at all since TI does not pay a fee and the revenue from the recycled commodities is less well defined and documented, since TI's goal is simply to cover the costs of new recycling equipment and internal recycling expenses. Under RM, a contractor would have an incentive to secure highest rates of return, and to track and document this information more fastidiously, since it is being compensated on this basis.

[5] For example, at $70 per ton on 962 tons disposed in 2000, incineration costs should be on the order of $68,000.

Table 5: Summary of Standard RM Practices and TI Implementation

RM Practice	Description	Present
1. Establish Baseline Cost, Performance and Service Levels	♦ Define scope and service levels	X
	♦ Identify existing contract and compensation methods	X
	♦ Validate service levels with total costs	
	♦ Establish cost and performance benchmarks and goals	X
2. Seek Strategic Input from Contractors	♦ Convene pre-bid meetings with contractors to articulate goals and address questions	
	♦ Allow or require bidders to submit operations plans for achieving specified improvements in existing operations	
3. Align Waste and Resource Efficiency Services	♦ Coordinate, integrate, and formalize all contracts and services included in the baseline scope identified in Practice 1	
	♦ Ensure that contractor has access to "internal" stakeholders that influence waste management and generation	
4. Establish Transparent Pricing for Services	♦ Delineate pricing information for specific services such as container maintenance, container rental, hauling, incineration, etc.	X
	♦ Allow variable price savings, such as "avoided hauling and incineration" to flow back to generator and/or be used as means for financing performance bonuses.	X
5. Cap Compensation for Garbage Service	♦ Constrain waste hauling/incineration service compensation by capping or changing to "on-call service."	X
	♦ De-couple contractor profitability from waste generation and/or service levels by setting decreasing cap based initially on reasonable estimates of current hauling and incineration service and costs as per practice 1.	
6. Provide Direct Financial Incentives for Resource Efficiency	♦ Establish compensation that allows contractor to realize financial benefits for service improvements and innovations.	
	♦ Assess liquidated damages for failing to achieve minimum performance benchmarks or standards.	

2. *Seek strategic input from prospective contractors.* Providing its resource efficiency goals and soliciting input in the pre-bid phase would allow TI to explore the extent to which prospective contractors can propose alternative solutions and pricing structures in an "open"[6] bid. A major advantage of this approach is that it is flexible and allows TI to explore the extent to which vendors are willing and able to identify and provide cost-effective improvements to existing services.

   TI has in the past solicited performance-based bids for non-waste related services, and has been successful in establishing value-added strategic partnerships with vendors. In these cases, strategic input continues after conclusion of the competitive

[6] An open specification includes performance-based objectives in place of limiting requirements to location, service level, number of containers and pick-ups exclusively, leaving it open to bidders how they propose to satisfy performance objectives.

process. For example, for its safety glove contract, TI's vendor is responsible for maintaining product specifications, and timely delivery of safety gloves that meet the requirements of different jobs within the manufacturing operation.

Likewise, RM comports with TI's supply chain strategy, and leads naturally to the development of a strategic partnership. This can be attributed to the fact that the contractor's profitability now rests in applying its expertise, in cooperation with TI staff, to increase recycling and achieve mutually-established waste reduction goals. Under its current contract, in which the recycling service has been handled as a component of the larger waste contract by at least two sub-contractors, there is a limited opportunity and incentive to create a partnership for recycling improvement.

3. *Align garbage, reduction and recycling services.* TI has focused on aligning services internally by making recycling convenient and deemphasizing trash incineration capacity. However, contractual means can also be applied to encourage recycling/ source reduction activities and constrain incineration.

   Current recycling services were established as a contractual responsibility of the waste vendor. As a result, the recycling is not a core part of its business, does not drive its profitability, and is therefore not an on equal footing with trash service. RM seeks to coordinate services so that waste management and recycling elements of an RM program are mutually reinforcing in support of resource efficiency goals. For instance, because the RM contractor profits from documented improvement, it would have an incentive to coordinate with the cafeteria service or purchasing department on source reduction of supplies. This would alleviate some of the burden on TI staff and management.

4. *Establish transparent pricing for services.* TI has benefited from having its waste contractor "unbundle" pricing structures to specify hauling on a fixed basis, and incineration on a variable basis (i.e., $ per ton incinerated). This allows TI to realize savings on the tonnage of materials disposed and the number of required hauls as suggested by the scenarios discussed in section 3 above. Furthermore, TI has negotiated gain-sharing arrangements on recycled commodities such as paper and plastic. These dual savings could be used to finance performance bonuses and/or assess reasonable liquidated damages as described in practice 6.

5. *Cap compensation for incineration service.* TI has effectively limited its trash contractor's ability to profit from ever-increasing garbage service levels by implementing on-call service for the majority of its trash compactors. This allows TI to realize cost savings from having the contractor service the containers less frequently than for a scheduled pick-up arrangement. TI has also fixed its contract such that costs do not increase by more than 5% per year. Looking ahead, TI might use its baseline trash cost information to negotiate a cap on what it is willing to pay for hauling/incineration service under an RM contract. The difference is that, under RM, this cost would ***decrease*** gradually over time based on reasonable estimates of current and expected service.

6. *Provide direct financial incentives for resource efficiency*. Savings on avoided hauling and incineration fees and revenues received for recycled commodities (as established in practice 4) could, in part, finance a performance bonus for increased diversion (see Tables 2 and 3). Optimizing recycling involves providing the right incentives to all of the recycling program stakeholders (employees and departments, TI environmental service staff, ***and*** contractors), and revising these incentives as the limits of recycling are reached to further provide incentives for source reduction.

RM presents a timely opportunity for TI to leverage cost-effective recycling and resource efficiency improvements by contractual means. Because TI has effectively captured most "low-hanging fruit" from improved recycling, RM may be one means for TI to institutionalize long-standing partnerships to achieve the next level of resource efficiency and improved services, and provide the contractor with a stream of profitable opportunities.